

Claims

1. A method for the nondestructive and contact-free detection of faults, particularly by means of eddy currents, in a test specimen (13) which is moved, at a speed (v), relative to a probe (14) that is characterized by an effective width (WB),
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a transmitter (12) being used to apply periodic electromagnetic alternating fields to the test specimen and the probe being used to detect a periodic electrical signal which has a carrier oscillation whose amplitude and/or phase is/are modulated as a result of a fault (15) in the test specimen if the fault reaches the effective width of the probe,
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the probe signal being filtered using a frequency-selective first filter unit (18),
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the signal which has been filtered using the first filter unit being sampled by means of a triggerable A/D converter stage (35) in order to obtain a demodulated digital measurement signal,
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the digital measurement signal being filtered using a digital frequency-selective adjustable second filter unit (52) in order to obtain a useful signal, and
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the useful signal being evaluated in order to detect a fault in the test specimen,
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the A/D converter stage being triggered at an nth integer fraction of the frequency of the carrier oscillation, n being selected as a function of the fault frequency which is obtained as the quotient

- of the relative speed between the test specimen and the probe and the effective width of the probe, and the frequency-selective second filter unit being adjusted as a function of the fault frequency.
5. The method as claimed in claim 1, characterized in that the relative movement between the test specimen (13) and the probe (14) results from the test specimen being moved linearly with respect to the probe.
10. 2. The method as claimed in claim 1, characterized in that the relative movement between the test specimen (13) and the probe results from the probe rotating with respect to the test specimen.
15. 3. The method as claimed in claim 1, characterized in that the relative movement between the test specimen and the probe results from the probe rotating with respect to the test specimen.
20. 4. The method as claimed in one of the preceding claims, characterized in that the transmitter is a coil (12) to which a radiofrequency AC voltage in the frequency range from 1 kHz to 5 MHz is applied in order to induce eddy currents in the test specimen (13), the probe being a coil arrangement (14) in which the eddy currents induce the periodic signal.
25. 5. The method as claimed in one of the preceding claims, characterized in that the transmitter (12) is supplied with an AC voltage in order to generate the periodic electromagnetic alternating fields, the AC voltage being generated from a binary signal by curve shaping.
30. 6. The method as claimed in claim 5, characterized in that the trigger signal for the A/D converter stage (35) is generated by dividing the frequency of the binary signal that is used to generate the AC voltage for the transmitter (12) by n.
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7. The method as claimed in one of the preceding claims, characterized in that n is selected to be inversely proportional to the fault frequency in order to select the trigger rate of the A/D converter stage (35) to be at least approximately proportional to the fault frequency.
8. The method as claimed in one of the preceding claims, characterized in that n is selected in such a manner that at least 5, preferably at least 20, sampling operations are carried out by the A/D converter stage (35) in an interval of time which corresponds to the inverse of the fault frequency.
9. The method as claimed in one of the preceding claims, characterized in that n is selected in such a manner that at most 100, preferably at most 50, sampling operations are carried out by the A/D converter stage (35) in an interval of time which corresponds to the inverse of the fault frequency.
10. The method as claimed in one of the preceding claims, characterized in that the frequency-selective second filter unit (52) is automatically adjusted as a function of the fault frequency by the second filter unit being clocked at the sampling rate of the A/D converter stage (35).
11. The method as claimed in one of the preceding claims, characterized in that the second filter unit (52) has a low-pass filter in order to remove interference components of the demodulated digital signal at frequencies higher than the fault frequency, the cut-off frequency of the low-pass filter being higher than the fault frequency, preferably higher than twice the fault frequency.

12. The method as claimed in one of the preceding claims, characterized in that the second filter unit (52) has a high-pass filter in order to remove DC components of the demodulated digital signal, the cut-off frequency of the high-pass filter being less than the fault frequency, preferably less than a quarter of the fault frequency.
- 10 13. The method as claimed in one of the preceding claims, characterized in that the frequency of the carrier oscillation is selected in such a manner that it is at least ten times the fault frequency.
- 15 14. The method as claimed in one of the preceding claims, characterized in that, when it is triggered, the A/D converter stage (35) samples two values, in a manner offset by a fixed phase difference, in order to obtain the digital measurement signal in the form of a two-component signal.
- 20 15. The method as claimed in claim 14, characterized in that the phase difference is 90° or $m * 360^\circ + 90^\circ$, where m is an integer.
- 25 16. The method as claimed in claim 14 or 15, characterized in that the two components of the digital measurement signal which is provided by the A/D converter stage (35) are filtered separately using the second filter unit (52) in order to obtain the useful signal in the form of a two-component signal.
- 30 17. The method as claimed in claim 16, characterized in that the two components are taken into account when evaluating the useful signal.

18. The method as claimed in one of the preceding claims, characterized in that the application of the electromagnetic alternating fields to the test specimen (13) using the transmitter (12) is interrupted at least for part of each interval between two successive trigger signals for the A/D converter stage (35).
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19. The method as claimed in one of the preceding claims, characterized in that the first filter unit (18) has at least one low-pass filter which acts as an aliasing filter as regards the sampling by the A/D converter stage (35).
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- 15 20. The method as claimed in one of the preceding claims, characterized in that the first filter unit (18) has a high-pass filter in order to remove low-frequency interference signals.
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21. The method as claimed in one of the preceding claims, characterized in that the speed (v) of the test specimen (13) is determined by means of measurement or is firmly prescribed as a parameter.
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22. The method as claimed in one of the preceding claims, characterized in that a controllable amplifier (16) is connected upstream of the A/D converter stage (35) in order to change the signal to the amplitude which is optimally suited to the A/D converter stage.
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23. The method as claimed in claim 1, characterized in that the transmitter uses electromagnetic excitation to generate sound waves in the test specimen, and the probe detects sound waves in the test specimen and converts them into the periodic electrical signal.
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24. The method as claimed in claim 1, characterized in
that the transmitter radiates microwaves into the
test specimen, and the probe converts microwaves
5 into the periodic electrical signal.
25. An apparatus for the nondestructive and contact-
free detection of faults (15), particularly by
means of eddy currents, in a test specimen (13)
10 which is moved, at a speed (v), relative to a
probe (14) that is characterized by an effective
width (WB), said apparatus having

15 a device (17) for detecting the relative speed
between the test specimen and the probe,

20 a transmitter (12) for applying periodic
electromagnetic alternating fields to the test
specimen,

25 the probe for detecting a periodic electrical
signal which has a carrier oscillation whose
amplitude and/or phase is/are modulated as a
result of a fault in the test specimen if the
fault reaches the effective width of the probe,

30 a frequency-selective first filter unit (18) for
filtering the probe signal,

35 a triggerable A/D converter stage (35) for
sampling the signal which has been filtered using
the first filter unit in order to obtain a
demodulated digital measurement signal,

a drive device (37) for triggering the A/D
converter stage at an nth integer fraction of the
frequency of the carrier oscillation, n being
selected as a function of the fault frequency

which is obtained as the quotient of the relative speed between the test specimen and the probe and the effective width of the probe,

5 a digital frequency-selective second filter unit (52) which can be adjusted as a function of the fault frequency and is intended to filter the digital measurement signal for the purpose of obtaining a useful signal, and

10 an evaluation unit (50) for evaluating the useful signal for the purpose of detecting a fault in the test specimen.

15 26. The apparatus as claimed in claim 25, characterized in that the probe (14) is in the form of a differential coil or an absolute coil for measuring eddy currents.

20 27. The apparatus as claimed in either of claims 25 and 26, characterized in that a binary signal source (44, 48) and a curve shaper (40) are provided in order to generate a supply voltage signal for the transmitter (12) from a binary signal by means of curve shaping.

25 28. The apparatus as claimed in claim 27, characterized in that the drive device (37) has a divider (30) in order to generate the trigger signal for the A/D converter stage (35) from the binary signal for the curve shaper (40) by dividing said binary signal by n .

30 29. The apparatus as claimed in claim 28, characterized in that the binary signal source is in the form of a timer (44).

30. The apparatus as claimed in one of claims 25 to 29, characterized in that the A/D converter stage (35) has a resolution of at least 16 bits.
- 5 31. The apparatus as claimed in one of claims 25 to 30, characterized in that the A/D converter stage (35) has at least one flash converter or SAR converter.
- 10 32. The apparatus as claimed in one of claims 25 to 31, characterized in that the second filter unit (52) is formed by a digital signal processor (40).
- 15 33. The apparatus as claimed in one of claims 25 to 32, characterized in that the A/D converter stage (35) has two A/D converters (32, 34) which are connected in parallel, the two A/D converters being triggered at the same frequency in such a manner that they sample in a manner offset by a fixed phase difference in order to obtain the digital measurement signal in the form of a two-component signal.
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